

Use of Ionic Liquids in Produced-Water Clean-up

FEAC332

Program

This project was funded through DOE's Natural Gas and Oil Technology Partnership Program. The program establishes alliances that combine the resources and experience of the nation's petroleum industry with the capabilities of the national laboratories to expedite research, development, and demonstration of advanced technologies for improved natural gas and oil recovery.

Project Goal

The goal was to use novel hydrophobic ionic liquid solvents for removal of organics from produced water. Chemical distribution factors were measured for major classes of organics: acids, paraffins, ketones, alcohols, and aromatics. The efficiency of the process was demonstrated using a centrifugal contactor for separation of immiscible liquid phases.

Performers

*Oak Ridge National Laboratory (ORNL)
Oak Ridge, TN*

*ConocoPhillips
Houston, TX*

*Shell Oil Co.
Houston, TX*

*ChevronTexaco
San Ramon, CA*

Project Results

The project has demonstrated that hydrophobic ionic liquids can preferentially remove selected organics from an aqueous phase. Efficient separation techniques have been developed using state-of-the-art centrifugal contactor technology.

Benefits

The produced-water waste stream is of concern to all oil producers, large companies as well as small, independent producers. Offshore and onshore facilities alike will benefit from the ability to remediate produced water using methods that are both efficient and cost-effective. Research into a new approach, such as applying ionic liquids to solving problems with produced water, will assist all producers to



Effluent samples collected from NaCl:bmim TF₂N separated in a centrifugal contactor.

comply with environmental regulations, ensuring a diverse and secure energy supply.

Background

Discharge of produced water in the Gulf of Mexico is regulated by National Pollutant Discharge Elimination System permits, which specify that total oil and grease in the water be below a daily maximum of 42 ppm. Remediation of the billions of barrels of water per annum of produced water often gives variable results because of the chemistry of the oil and its ability to buffer against pH changes. The problem is particularly severe for new wells, where the properties of the oil may change during production, and the amounts and types of the water-soluble organic compounds are not well-known. Hence the goal of this project will be to introduce a new approach to produced-water remediation, through solvent extraction using ionic liquids.

Project Summary

In the project, researchers:

- Selected ionic liquid solvents based on physical and chemical properties.
- Tested organic removal under conditions of temperature, salinity, and pH comparable to that found in produced water and published results.

- Demonstrated separation in a centrifugal contactor.

- Measured bulk-phase and interfacial properties key to separation efficiencies and published results.

Current Status (August 2005)

In this project, ORNL and industry partners have addressed questions regarding efficacy, regeneration, and selectivity of ionic liquid-based removal of polar organic compounds from produced water. For produced-water remediation, the ionic liquid must be immiscible with the aqueous phase. Hydrophobic ionic liquids have been synthesized in-house and have been tested in three ways:

- In liquid-liquid extraction of produced water contaminants (complete).
- Phase separation with a brine in a centrifugal contactor that has previously been used for oil/water separations (in progress).
- Physical properties measurements (in progress).

Publications

The work was published in two papers presented at the Separation Science and Technology Conference in Gatlinberg, KY, in October 2003 and at the National AICHE meeting in November 2004.

McFarlane, J., Ridenour, W.B., Luo, H., Hunt, R.D., DePaoli, D.W., and Ren, R.X., 2005, Room-Temperature Ionic Liquids for Separating Organics from Produced Water, *Separations Science and Technology* 40 (6), 1245-1265.

Toh, S.L.I., McFarlane, J., Tsouris, C., DePaoli, D.W., Luo, H., Dai, S., Room-Temperature Ionic Liquids in Liquid-Liquid Extraction: Effects of Solubility in Aqueous Solutions on Surface Properties.

Project Start: March 1, 2003

Project End: September 30, 2005; no-cost extension to December 31, 2005

Anticipated DOE Contribution: \$390,000

Performer Contribution: (in kind): \$78,000 (20% of total)

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